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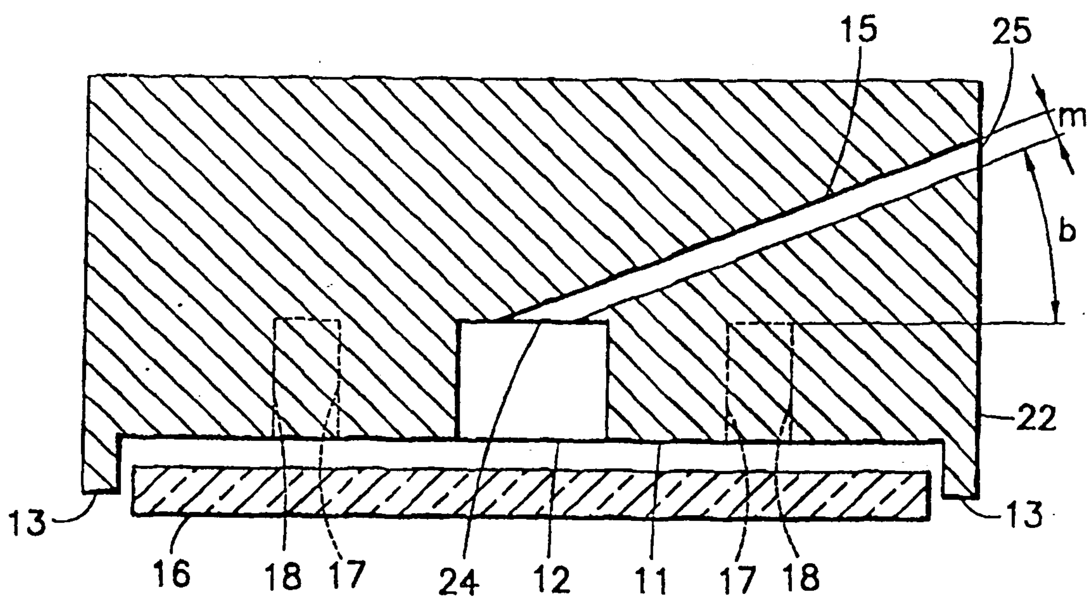

(57) Abstract

A holder for wafer-like articles is formed by providing a platform having a wafer-like article facing surface that includes at least one annular groove therein. The annular groove has a ceiling surface therein which is provided with an opening. A gas conducting conduit is connected to the opening. A gas, which introduced into the conduit, exits the conduit through the opening. By choosing a particular orientation of the conduit relative to the annular groove, the gas exiting the opening can be caused to circulate in a clockwise or counter clockwise fashion. The circular flow of gas causes the formation of a vortex adjacent to the article facing surface. A wafer-like article may be held in a suspended state adjacent to the wafer-like article facing surface without contact by the vortex and the gas flowing between the wafer-like article and the article facing surface.

NON-CONTACT HOLDER FOR WAFER-LIKE ARTICLES

BACKGROUND

Field of the Invention

The present invention relates to a holder for holding wafer-like articles without physical contact between the holder and the wafer-like article being held. More particularly, the present invention relates to an apparatus for holding articles through the use of a particular fluid dynamic relationship between the wafer-like article and the holder created by the structure of the holder.

Description of the Prior Art

The handling of wafer-like articles, such as silicon wafers, can present problems. Some prior art wafer-like article holding apparatus have mechanical latches to hold the article in place. The mechanical latches have drawbacks such as contact between the article and the holder. The contact can cause contamination of the article as well as induce mechanical stresses in the article.

Other prior art wafer-like article holders include vacuum or electrostatic chucks. These types of holders also have drawbacks. Such drawbacks include physical contact between the holder and the article which can cause contamination and mechanical damage. Also, because some actual pre-processed articles, such as wafers, are not flat, securing such articles on a flat holder by vacuum or electrostatic means can cause mechanical stresses in the article.

SUMMARY OF THE INVENTION

The present invention provides a holder for holding wafer-like articles without physical contact between the holder and the wafer-like article being held. The holder comprises a platform having an article facing surface which includes at least one annular groove therein formed by an inner wall, an outer wall and a ceiling surface between the inner and outer walls. The ceiling surface is provided with an opening. The holder further includes a gas conducting conduit which is connected to the opening in the ceiling surface of the annular groove. The gas

conducting conduit is oriented relative to the opening in the ceiling surface of the annular groove so as to cause a circular flow of gas around the annular groove when a gas is flowed down the conduit and through the opening.

One object of the present invention is to provide a wafer-like article holder that avoids physical contact between the wafer-like article and the holder.

Another object of the present invention is to provide a wafer-like article holder that does not induce mechanical stress in the wafer-like article while it is being held.

The foregoing and other objects, features, and advantages will become apparent from the detailed description of the preferred embodiments invention as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings, which are not drawn to scale, include:

FIG. 1A, which is a diagram plan view of one embodiment of the apparatus of the present invention;

FIG. 1B, which is a diagram plan view of an alternative embodiment of the apparatus of the present invention;

FIG. 2A, which is a sectional view of the embodiment illustrated in FIG. 1A taken along the line 2A--2A, and which also includes a wafer-like article adjacent to the apparatus;

FIG. 2B, which is a sectional view of the embodiment illustrated in FIG. 1A taken along the line 2B--2B, and which also includes a wafer-like article adjacent to the apparatus;

FIG. 3, which is a graph showing the relationship of the differential pressure with radial distance from the center of an annular groove in the apparatus;

FIG. 4, which is a graph showing the relationship between holding force applied to the wafer-like article and the distance between the surface of the wafer-like article adjacent the apparatus and the apparatus;

FIG. 5, which is a diagram plan view of another embodiment of the apparatus of the present invention illustrating four annular grooves;

FIG. 6, which is a schematic diagram plan view of an end effector which incorporates the structure of the present invention for creating a vortex;

FIG. 7, which is a schematic diagram elevational view of the end effector shown in FIG. 6; and

FIG. 8, which is a partial schematic diagram elevational view illustrating a rim comprised of fingers for preventing excessive lateral movement of the wafer-like article.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1A and 2, the wafer-like article holder of the present invention comprises a platform **10** having a flat wafer-like article facing surface **11**. The flat wafer-like article facing surface **11** includes at least one annular groove **12** therein formed by an inner wall **17** having a diameter $\mathbf{d_1}$, an outer wall **18** having a diameter **d** and a ceiling surface **14** between the inner **17** and outer **18** walls. The ceiling surface **14** is provided with an opening **24**. The wafer-like article holder of the present invention may also include a rim **13** about the perimeter of the platform **10**.

Still referring to FIGS. 1A and 2, a gas conducting conduit **15** having a diameter **m** is provided in the platform **10** between the opening **24** in the ceiling surface **14** of the annular groove **12** and a side **22** of the platform **10** at opening **25**. The conduit **15** is oriented in one aspect such that a component of its axis is substantially tangential to the circumference of the annular groove **12** in the plane formed by the article facing surface **11**. Preferably, the ceiling surface **14** is substantially parallel planar to the plane formed by flat wafer-like article facing surface **11**. The conduit **15** is also oriented in another aspect such that a component of the axis of the conduit **15** makes an angle **b** which is generally less than 90°, and preferably less than 45°, relative to the parallel plane formed by the ceiling surface **14** of annular groove **12**. Also, preferably, the diameter **m** of the conduit **15** is made smaller than the annular groove's depth **H**.

During operation, opening **25** is connected to a source of compressed gas. The compressed gas is flowed down conduit **15** to opening **24** where it exits. Because the conduit **15** is oriented relative to opening **24** the exiting gas flows around the annular groove **12**. The gas flowing around the annular groove **12** causes a vortex to be formed adjacent to the annular groove **12**. As will be explained below, the gas dynamics provided by the vortex hold the wafer-like article in place without contact.

Alternatively, as shown in FIG. 1B, the ceiling surface **14** of the annular groove **12** may be provided with a plurality of openings **24a-24d** and a plurality of conduits **15a-15d** providing a flow of compressed gas to the openings **24a-24d**. Each of the conduits **15a-15d** is oriented in the same manner as described above and in such a manner that each directs a flow of compressed gas out of the openings in the same direction around the annular groove **12**. The advantage to having a greater number of openings **24a-24d** and conduits **15a-15d** is that the vortex created can be better controlled so that it has less discontinuities.

The internal diameter d_1 of the annular groove **12**, which is established by the inner wall **17**, is chosen from the ratio system:

S(m))

S(m) to be corrected

$$d_1 < \text{minimum value of} \begin{cases} (d-2m) \\ (d^2-4n\dfrac{Scm)}{\pi})^{1/2} \end{cases}$$

IPEC Precis

where: d - diameter of the outer wall **18** of the annular groove **12** which is established by the outer wall **18**;

n - quantity of the openings **24** in the ceiling surface **14** of the annular groove **12**; and

S(m) - cross-sectional area of the opening **24**.

Through adjustments in the orientation of the gas conducting conduit **15** relative to opening **24** in the ceiling surface **14**, as well as adjustments in the size

of the annular groove, the gas dynamics created by the apparatus, i.e., the created vortex, can be optimized.

The wafer-like article holder of the present invention holds a wafer-like article **16** adjacent the article facing surface **11** through fluid dynamics caused by the delivery of compressed gas to opening **25**. The compressed gas is directed via conduit **15** to the opening **24** in the ceiling surface **14** of the annular groove **12**. The gas exits the opening **24** and moves around the annular groove **12** in either a clockwise or counter clockwise direction, depending on the orientation of the conduit **15** relative to the opening **24**, and therefore, relative to annular groove **12**. In either case, the clockwise or counterclockwise flowing gas forms a vortex. At the center of the vortex there is a region of relatively low pressure. As the angle **b** between the axis of the conduit **15** and the ceiling surface **14** of the annular groove **12** is decreased towards 0 degrees, the region of relatively low pressure caused by the vortex increases.

The diameter **m** of the conduit **15** should be made smaller than the depth **H** of the annular groove **12** to insure that the gas flows uniformly inside the annular groove **12** to create the vortex. If the annular groove's internal diameter d_1, established by inner wall **17** is chosen according to the ratio system (1) expressed above, such that the annular groove's cross-section (d-d_1) established by the inner **17** and outer **18** walls, and correspondingly the ceiling surface **14** width, is larger than area of opening **24**, vortex gas velocity reduction due to annular groove-gas dynamical resistance will be minimized or avoided altogether.

By flowing gas through opening **24** according to the present invention, a wafer-like article **16** may be held in place by merely positioning the wafer-like article **16** parallel to the flat wafer-like article facing surface **11** with the gap of about 0.1 - 1mm between the wafer-like article **16** and the flat wafer-like article facing surface **11**. The wafer-like article will be held in place adjacent to the flat wafer-like article facing surface **11** without physically contacting it.

The gas flowing out from the annular groove **12** flows along gap **h** between the wafer-like article **16** and flat wafer-like article facing surface **11** and forms radial flow which is continuous around the annular groove **12** and directed out of

it. As a result of the gas flow, a difference between the ambient gas pressure and the pressure in the gap **h** between the wafer-like article **16** and flat wafer-like article facing surface **11** is created. The typical pressure differential distribution as a function of radial distance is shown in FIG. 3.

Referring to FIG. 3, within a region in the annular groove **12** where **r** is less than **d/2**, the ambient gas pressure P_a (e.g. atmospheric pressure) is higher than the gas pressure P_h in the gap **h**, and the resulting pressure difference ΔP ($\Delta P = P_a - P_h$) is positive. This is the reason why the wafer-like article **16** is pressed to the wafer-like article holder **11** with force:

$$F(+) = 2\pi \int_{r=0}^{r=d/2} \Delta P(r)\, r\, dr$$

For a radius greater than the annular groove **12**, d/2, the ambient gas pressure is lower than the gas pressure in the gap **h**, and the pressure difference ΔP is negative. This is the reason why the wafer-like article **16** is pushed out of the wafer-like article holder with force (see Fig. 3):

$$F(-) = 2\pi \int_{d/2}^{D/2} \Delta P(r)\, r\, dr$$

This force F(-) does not allow the wafer-like article **16** to touch the wafer-like article facing surface **11**.

Both force values and their sum F = F(-)+F(+) depend on the gap size **h**. The wafer-like article equilibrium location is a gap size **h** where the wafer-like article weight W is compensated by the force F. Two configurations of the wafer-like article **16** with respect to the holder's surface **11** that meet the equilibrium conditions are when: (1) the wafer-like article **16** is placed below the holder

surface **11**; and (2) the wafer-like article **16** lies above the holder surface **11**. For the first case, provided the wafer-like article's weight **W** is less than the maximum net positive force, F_{max} of Fig. 4, the wafer-like article is drawn towards the holder surface **11** to an equilibrium position with gap **h1**. At this position, the downward force **W** is equal in magnitude and opposite in direction to the upward force supplied by the gas dynamics created by the holder. In the second case, gravity pulls the wafer-like article toward the holder surface 11 to an equilibrium position with gap **h2** less than gap **h1** where the negative force, pushing the wafer-like article **16** away from the holder surface **11**, balances the wafer-like article's weight **W**. Similarly, for any orientation of the wafer holder surface to the direction of gravity, there is an equilibrium gap **h** which the component of **W** normal to the holder surface **11** is balanced by a counteracting force F supplied by the holder 11. Consequently, provided there are retaining elements 13 FIG 2B & 8, the holder can hold the wafer-like article **16** in any orientation with no contact of the wafer-like article to the holder surface.

Analyzing FIG. 4 the advantages of the wafer-like article holder of the present invention become very apparent for the case when the holder is used to suspend the wafer-like article **16** because: a) the wafer-like article equilibrium position **h1** is a stable position because of small deviation of the wafer-like article's position causes counter forces to arise, that is important for reliable wafer-like article holding; b) the holder may "catch" the wafer-like article and bring it to it's equilibrium position **h1** from any distance in the range between **h1** and **h3** where the attractive force is higher than wafer-like article's weight, which may simplify loading the wafer-like article onto the holder; and c) due to the gas gap between the wafer-like article and the holder the wafer-like article does not need to be flat or change its flatness during a treatment (thermal elastic deformation) without additional stress or degradation of holding reliability if the non-flatness magnitude is comparable with the gas gap size.

In processing applications and specifically for plasma processing applications, there may be heat input to the surface of the wafer-like article. Heat must be effectively removed so that there is not thermal degradation of the wafer-

like article (e.g., damage to semiconductor IC circuits, thermally diffusing contaminants into a semiconductor wafer). Heat must be uniformly removed; otherwise, non-uniform processing for thermally dependent processes will occur (e.g., non uniform etching of a material from the wafer-like article with an etch process whose rate is temperature dependent). Consequently, the close proximity to the surface of the wafer-like article (i.e., less than 1mm) provides efficient heat transfer across the wafer-like article to holder surface gap **h**. Also, because the holder's surface **11** has no large holes or discontinuities in its surface, only annular grooves which are small in size as compared to the entire surface area of surface **11**, the rate of heat transfer from the wafer-like article to the holder is substantially uniform across its area.

Referring to FIG. 5, flat wafer-like article facing surface **11** may be provided with a plurality of annular grooves, such as the plurality of annular grooves **112a-112d**. As illustrated in FIG. 5, when a plurality of annular grooves are employed, the quantity of annular grooves is preferably chosen in multiples of two. Each annular groove **112a-112d** has a conduit **115a-115d** connected to an opening **124a-124d** in the ceiling surface. The conduits are connected to a source of compressed gas. Each of the conduits **115a-115d** is selectively oriented in an opposite direction from a conduit of an immediately adjacent annular groove. For example, in the embodiment shown in FIG. 5, two of the annular grooves **112a** and **112c**, forming a first plurality of annular grooves, have openings **124a** and **124c** which are connected to a first plurality of gas conducting conduits, conduits **115a and 115c**, which are oriented relative to the annular grooves **112a** and **112c** to cause a counter clockwise flow around each. The remaining two annular grooves **112b** and **112d**, forming a second plurality of annular grooves, have openings **124b** and **124d** connected to a second plurality of conduits, such as conduits **115b** and **115d**, which are oriented relative to the annular grooves **112b** and **112d** to cause a clockwise flow around each. The opposite rotation of gas in the adjacent annular grooves allows the rotational influences of the vortexes on the wafer-like article to cancel and the wafer-like article **16** does not rotate relatively the flat wafer-like article facing surface **11**.

Referring to FIGS. 6 and 7, there is shown a fork-shaped end effector **40** for picking up, transporting and holding wafer-like articles in any orientation. With the fork-shaped end effector **40**, the orientation of the wafer-like article may be changed during transport to allow, for example, removal from a station in which it is face-down and loaded into a wafer-like article holder, such as the holder described above, for processing with a face-up orientation. Also, the fork-shaped end effector **40** can be made to allow removal from and into stations with little dimensional clearance. For examples where the wafer-like article is a semiconductor wafer or a glass plate used for lithographic exposure of semiconductor wafer patterns, standard packing is in multiple, stacked configurations with little spacing between the articles and only limited areas of open space around the article's edge. The fork-shaped end effector **40** can be made thin (e.g., less than about 2.5 mm) to fit between stacked, wafer-like articles and with lateral dimensions that fit into open space around the edges.

The end effector **40** is formed by a substantially planar thin fork-shaped platform **42** having first and second prong regions **43a-43b** located at first end **44** and a base region **45** adjacent to second end **46**. The platform further includes a pair of sides **48a** and **48b**. Preferably, the sides **48a** and **48b** taper outwardly from the first end **44** towards a point **50** between the first and second ends. From point **50**, the sides **48a** and **48b** taper inwardly toward the second end **46**.

An even numbered plurality of annular grooves **52a-52d** are provided in the platform **42**. Each of the plurality of annular grooves is constructed in a similar fashion as described above. Each has inner and outer walls and a ceiling surface which spans the inner and outer walls. The ceiling surface of each of the plurality of annular grooves is provided with an opening. The openings in half of the even numbered plurality of annular grooves, **52a** & **52c**, are supplied with a flow of gas by corresponding gas conducting conduits **54a** & **54c**, which are oriented relative to the annular grooves so as to direct the flow of gas in a counter-clockwise fashion. The openings in the other half of the even numbered plurality of annular grooves **52b** & **52d** are supplied with a flow of gas by corresponding gas conducting conduits **54b** & **54d**, which are oriented relative to the annular grooves

so as to direct the flow of gas in a clockwise fashion. Annular grooves **52a** and **52d** are provided on first and second prong regions **43a** and **43b** respectively. Annular grooves **52b** and **52c** are provided on the base region **45** of the platform **42**. Gas conducting conduits **54a-54d** may be made from hypodermic tubing.

The second end **46** of platform **42** is connected to extension member **56** and the extension member **56** is attached to a gas manifold **58**. The gas conducting conduits **54a-54d** are connected to gas manifold **58** which has inlet **60** connected to a supply of compressed gas (not shown).

Preferably, the platform is provided with first and second rim sections **62a** and **62b**. The first rim **62a** is positioned adjacent to the first end **44**, while second rim section **62b** is positioned adjacent section to the second end **46**. The rim sections prevent the wafer-like article from moving laterally off of the platform.

Referring to FIG. 8, in the embodiment of the invention illustrated in FIG. 1A, the flat wafer-like article facing surface **11** is provided with rim **13** having an inner surface **30**, an outer surface **32** and an end **34**. The rim is positioned along the facing surface's perimeter or edge. The rim **13** is intended to function as a boundary to retain the wafer-like article adjacent to the flat wafer-like article facing surface **11** because the wafer-like article **16** has no mechanical contact and no friction with the wafer-like article facing surface **11**, the wafer-like article **16** could shift relative to the facing surface **11**. Preferably, the end **32** of the rim **13** extends out from the article facing surface **11** by a distance **L**, which is typically more than 1mm because the equilibrium gap size **h** is typically not more than 1 mm. While the rim **13** may be continuous along the perimeter, alternatively, the rim **13** may comprise a plurality of periodically spaced apart fingers, such as that shown in FIG. 8. The fingers make the wafer-like article's edges more open to treatment agents than a continuous rim. In a preferred embodiment, the inner surface **30** of the rim **13** or the inner surface **30** of each of the plurality of fingers comprising a rim 13, may be made to have angle a which is greater than 90° relative to the plane formed by the wafer-like article facing surface **11**. The purpose of angling the rim is to reduce "shadow" effects caused by the rim **13** during treatment (as an example, plasma treatment) of the article **16**.

According to the present invention, in any embodiment, such as that shown in FIGS. 1A, 1B, 5, 6 and 7, for example, the flat wafer-like article facing surface **11** is provided with dimension **D** which is always greater than the dimension $\mathbf{D_1}$ of the wafer-like article **16**. In other words, the wafer-like articles which may be held by the apparatus of the present invention will always have dimensions which are less than the dimensions of the article facing surface **11**. The wafer-like article facing surface **11** size **D** should be more than the wafer-like article dimension $\mathbf{D_1}$ to allow the wafer-like article to take it's equilibrium position without interference from the rim **13**.

As will be understood from the foregoing description, according to the present invention, several embodiments of a wafer-like article holder have been described which use gas dynamics to hold the article without physical contact between the holder and the article. The present invention adequately provides a means for meeting the requirements for holding wafer-like articles for the purposes of processing the side of the wafer-like article facing away from the holder's surface, particularly with a reactive gas generated by an electrical discharge and for transporting the wafer like article. It is to be understood that the embodiments described herein are merely illustrative of the principles of the invention. Various modifications may be made thereto by persons skilled in the art which will embody the principles of the invention and fall within the spirit and scope thereof. Hence, the present invention is deemed limited only by the appended claims and the reasonable interpretation thereof.

What Is Claimed Is:

1. A holder for holding wafer-like articles without physical contact between the holder and the wafer-like article being held, the holder comprising:

a platform having an article facing surface, the article facing surface further including an annular groove therein formed by an inner wall, an outer wall and a ceiling surface between the inner and outer walls, the ceiling surface further including an opening therein; and

a gas conducting conduit connected to the opening in the ceiling surface of the annular groove, wherein the gas conducting conduit is oriented relative to the opening in the ceiling surface of the annular groove so as to cause a circular flow of gas around the annular groove when a gas is flowed down the conduit and through the opening.

2. The holder of claim 1, wherein the gas conducting conduit is oriented so as to be substantially tangential to the annular groove's circumference which is in the same plane as a plane formed by the article facing surface.

3. The holder of claim 1, wherein the ceiling surface is substantially planar and the gas conducting conduit forms an angle **b** with respect to the plane formed by the ceiling surface and wherein angle **b** is in the range of 0 to 45 degrees.

4. The holder of claim 2, wherein the ceiling surface is substantially planar and the gas conducting conduit forms an angle **b** with respect to the plane formed by the ceiling surface and wherein angle **b** is in the range of 0 to 45 degrees.

5. The holder of claim 1, wherein the annular groove in the article facing surface has a depth H, wherein the gas conducting conduit has a diameter m, and wherein diameter m is smaller than depth H.

6. The holder of claim 4, wherein the annular groove in the article facing surface has a depth H, wherein the gas conducting conduit has a diameter m, and wherein diameter m is smaller than depth H.

7. The holder of claim 1, wherein the opening in the ceiling surface is smaller than the ceiling surface.

8. The holder of claim 1, wherein the ceiling surface is provided with a plurality of openings, and wherein the holder is further provided with a plurality of gas conducting conduits, each of the openings being connected to a gas conducting conduit, each of the gas conducting conduits being oriented relative to its respective opening so as to cause a circular flow of gas around the annular groove in the same direction when a gas is flowed down the conduit and through the associated opening.

9. The holder of claim 1, wherein the article facing surface is provided with a rim extending therefrom, the rim having an inner surface which faces the annular groove, an outer surface and an end.

10. The holder of claim 9, wherein the rim is substantially continuous.

11. The holder of claim 9, wherein the rim is formed from a plurality of spaced apart fingers.

12. The holder of claim 9, wherein the inner surface of the rim forms angle a with respect to the plane formed by the wafer-like article facing surface, and wherein angle a is greater than 90 degrees.

13. The holder of claim 1, wherein the article facing surface is provided with a second annular groove formed by a second inner wall, a second outer wall

and a second ceiling surface between the second inner and outer walls, the second ceiling surface further including an opening therein; and

a second gas conducting conduit connected to the opening in the second ceiling surface of the second annular groove, wherein the second gas conducting conduit is oriented relative to the opening in the second ceiling surface of the second annular groove so as to cause a circular flow of gas around the second annular groove when a gas is flowed down the second conduit and through the opening, and wherein the circular flow of gas around the second annular groove is in a direction which is opposite to the direction of the circular flow of gas around the other annular groove.

14. The holder of claim 1, wherein the gas conducting conduit is formed from a hypodermic tube.

15. A holder for holding wafer-like articles without physical contact between the holder and the wafer-like article being held, the holder comprising:

a platform having an article facing surface, the article facing surface further having a first even numbered plurality of annular grooves therein formed by inner walls, outer walls and ceiling surfaces between the inner and outer walls, the ceiling surfaces further including an opening therein, and a second even numbered plurality of annular grooves therein formed by inner walls, outer walls and ceiling surfaces between the inner and outer walls, the ceiling surfaces further including an opening therein;

a first plurality of gas conducting conduits, wherein each opening in the ceiling surface of the first plurality of annular grooves is connected to one of the conduits of the first plurality of gas conducting conduits and wherein each of the conduits of the first plurality of gas conducting conduits is oriented relative to the opening so as to cause a clockwise circular flow of gas around the annular groove when a gas is flowed down the conduit and through the opening; and

a second plurality of gas conducting conduits, wherein each opening in the ceiling surface of the second plurality of annular grooves is connected to one of

the conduits of the second plurality of gas conducting conduits and wherein each of the conduits of the second plurality of gas conducting conduits is oriented relative to the opening so as to cause a counter clockwise circular flow of gas around the annular groove when a gas is flowed down the conduit and through the opening.

16. The holder of claim 15, wherein the conduits are formed from hypodermic tubes.

17. The holder of claim 15, wherein the platform further includes a rim extending from the article facing surface.

18. A holder for holding wafer-like articles without physical contact between the holder and the wafer-like article being held, the holder comprising:

a fork-shaped platform having an article facing surface formed by a first prong region, a second prong region and a base region;

a first annular groove formed in the first prong region by an inner wall, an outer wall and a ceiling surface between the inner and outer walls, the ceiling surface further including an opening therein;

a first gas conducting conduit connected to the opening in the ceiling surface of the first annular groove, wherein the first gas conducting conduit is oriented relative to the opening in the ceiling surface of the first annular groove so as to cause a circular flow of gas around the annular groove when a gas is flowed down the conduit and through the opening;

a second annular groove formed in the second prong region by an inner wall, an outer wall and a ceiling surface between the inner and outer walls, the ceiling surface further including an opening therein;

a second gas conducting conduit connected to the opening in the ceiling surface of the first annular groove, wherein the second gas conducting conduit is oriented relative to the opening in the ceiling surface of the second annular groove so as to cause a circular flow of gas around the annular groove when a gas is

flowed down the conduit and through the opening, and wherein the circular flow of gas around the second annular groove is in a direction which is opposite to the direction of the circular flow of gas around the first annular groove;

a third annular groove formed in the base region by an inner wall, an outer wall and a ceiling surface between the inner and outer walls, the ceiling surface further including an opening therein;

a third gas conducting conduit connected to the opening in the ceiling surface of the third annular groove, wherein the third gas conducting conduit is oriented relative to the opening in the ceiling surface of the third annular groove so as to cause a circular flow of gas around the annular groove when a gas is flowed down the conduit and through the opening, and wherein the circular flow of gas around the third annular groove is in a direction which is the same as the direction of the circular flow of gas around the first annular groove;

a fourth annular groove formed in the base region by an inner wall, an outer wall and a ceiling surface between the inner and outer walls, the ceiling surface further including an opening therein; and

a fourth gas conducting conduit connected to the opening in the ceiling surface of the fourth annular groove, wherein the fourth gas conducting conduit is oriented relative to the opening in the ceiling surface of the fourth annular groove so as to cause a circular flow of gas around the annular groove when a gas is flowed down the conduit and through the opening, and wherein the circular flow of gas around the fourth annular groove is in a direction which is opposite to the direction of the circular flow of gas around the first annular groove.

19. The holder of claim 18, wherein the first prong region, the second prong region and the base region are provided with a rim.

20. The holder of claim 18, wherein the first, second, third and forth gas conducting conduits are connected to a gas supplying manifold which is attached to an end of the platform adjacent to the base region.

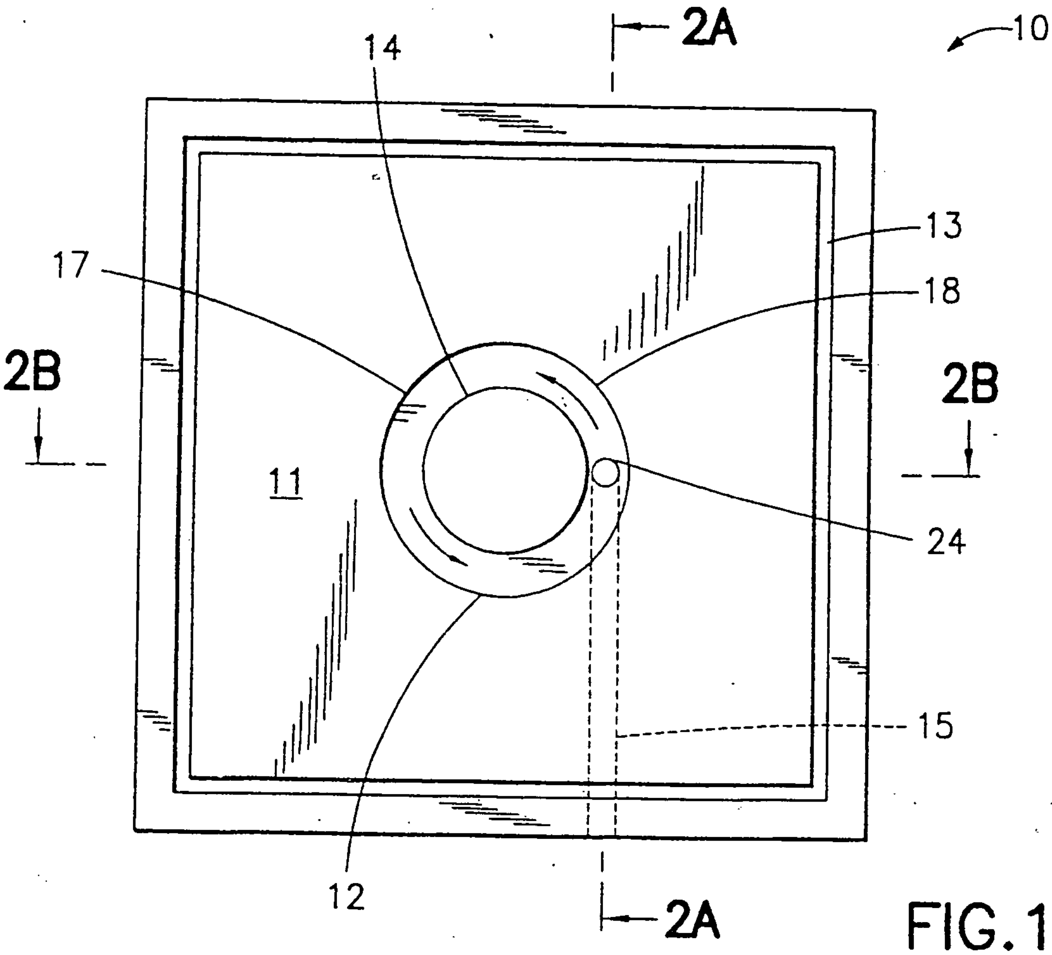
2A
10
14
13
17
18
2B
2B
11
24
15
12
2A

FIG.1A

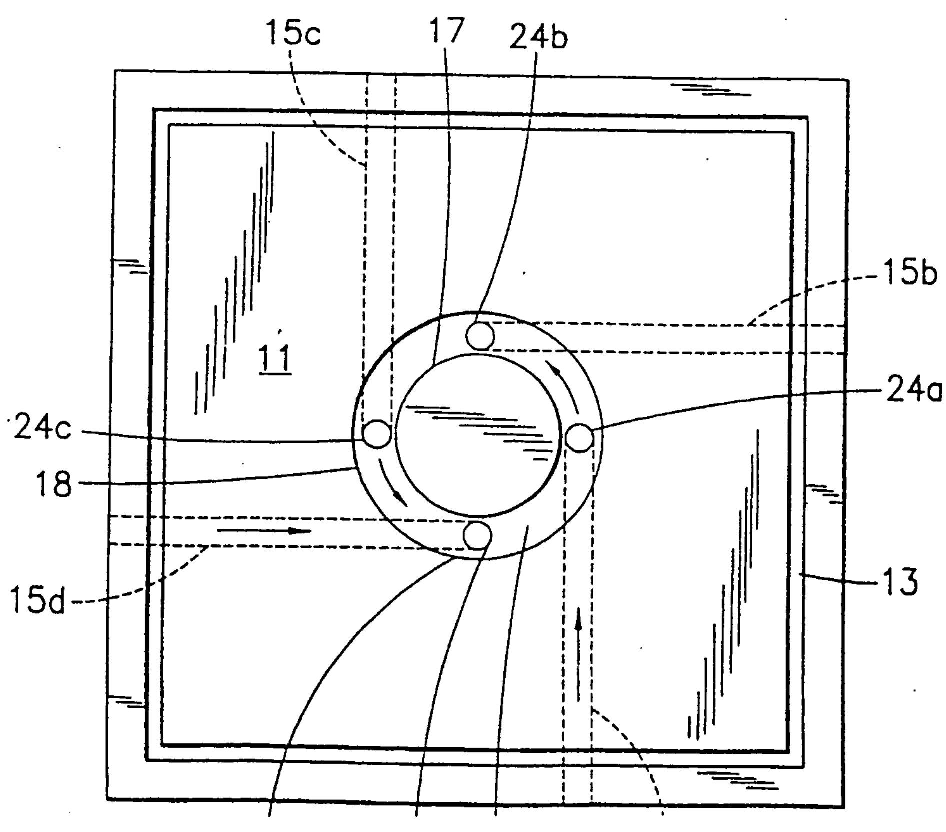
15c
17
24b
10
15b
11
24a
24c
18
15d
13

FIG.1B

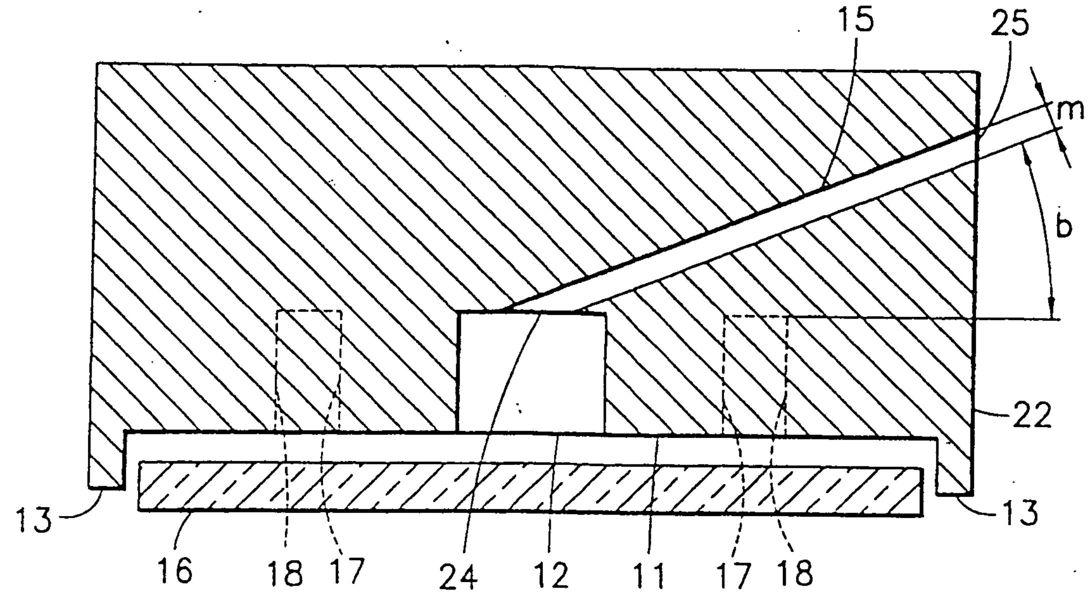
15
25
m
b
22
13
13
16
18
17
24
12
11
17
18

FIG.2A

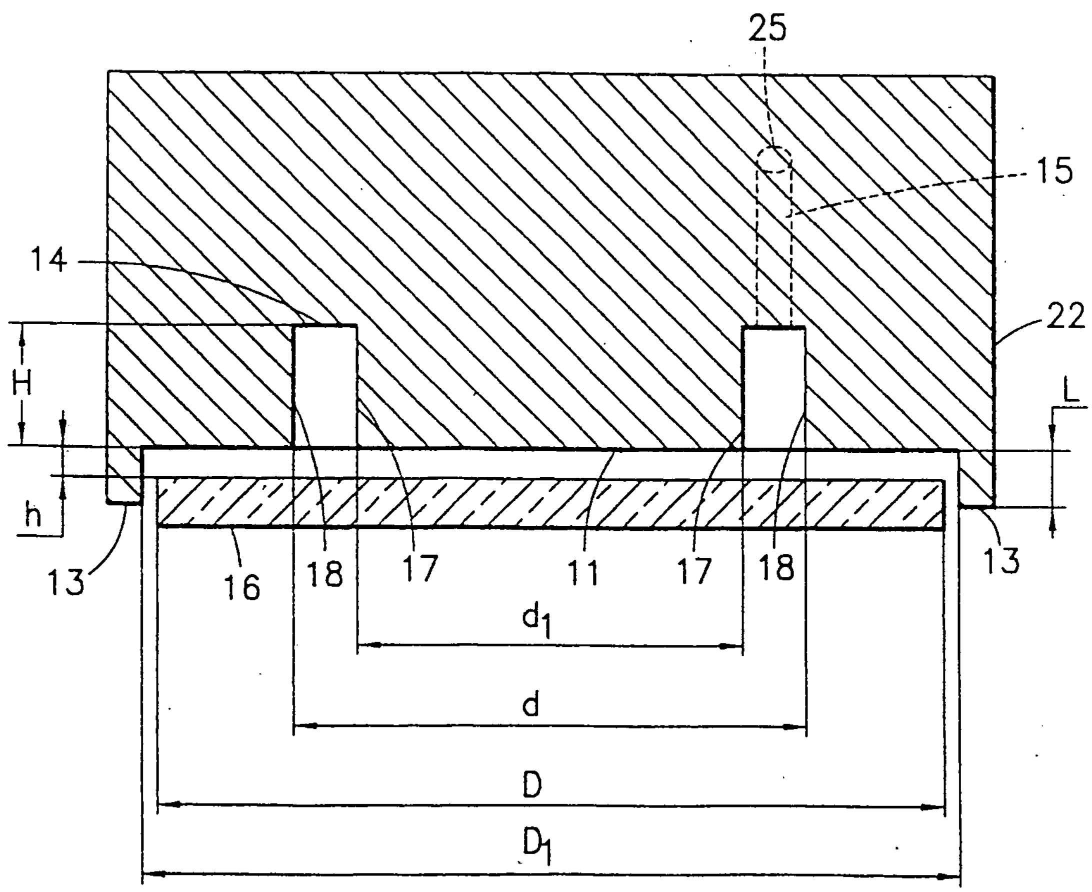
25
15
14
22
H
L
h
13
16
18
17
11
17
18
13
d_1
d
D
D_1

FIG.2B

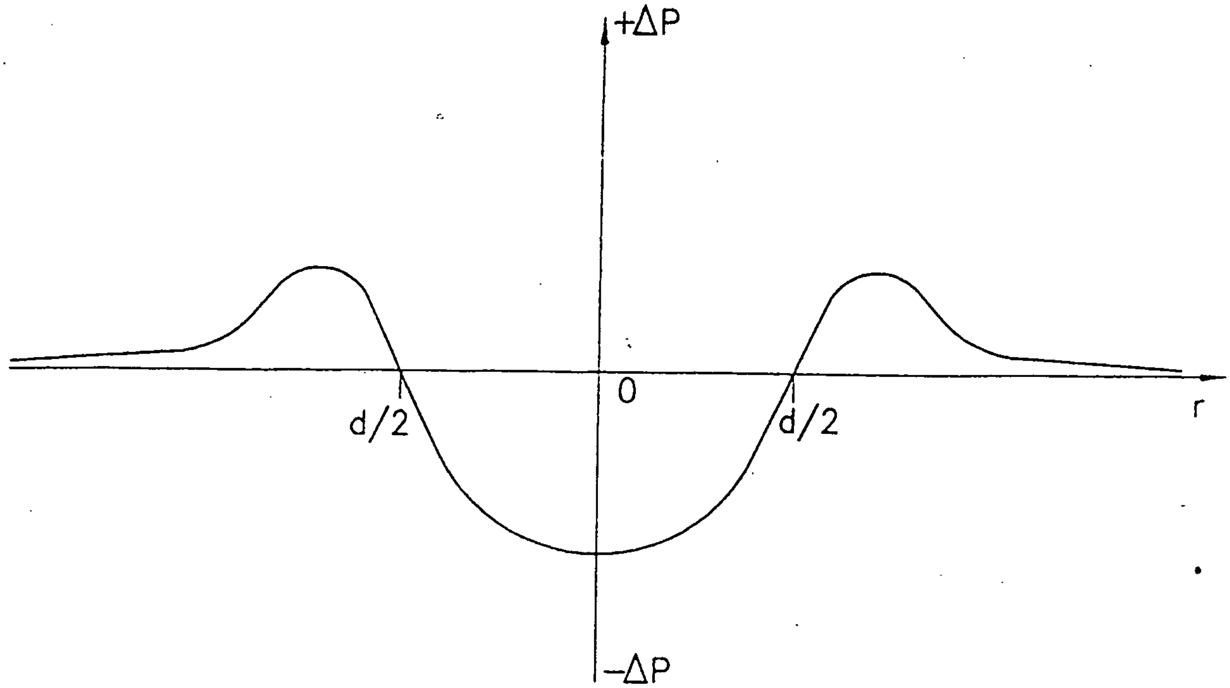

FIG.3

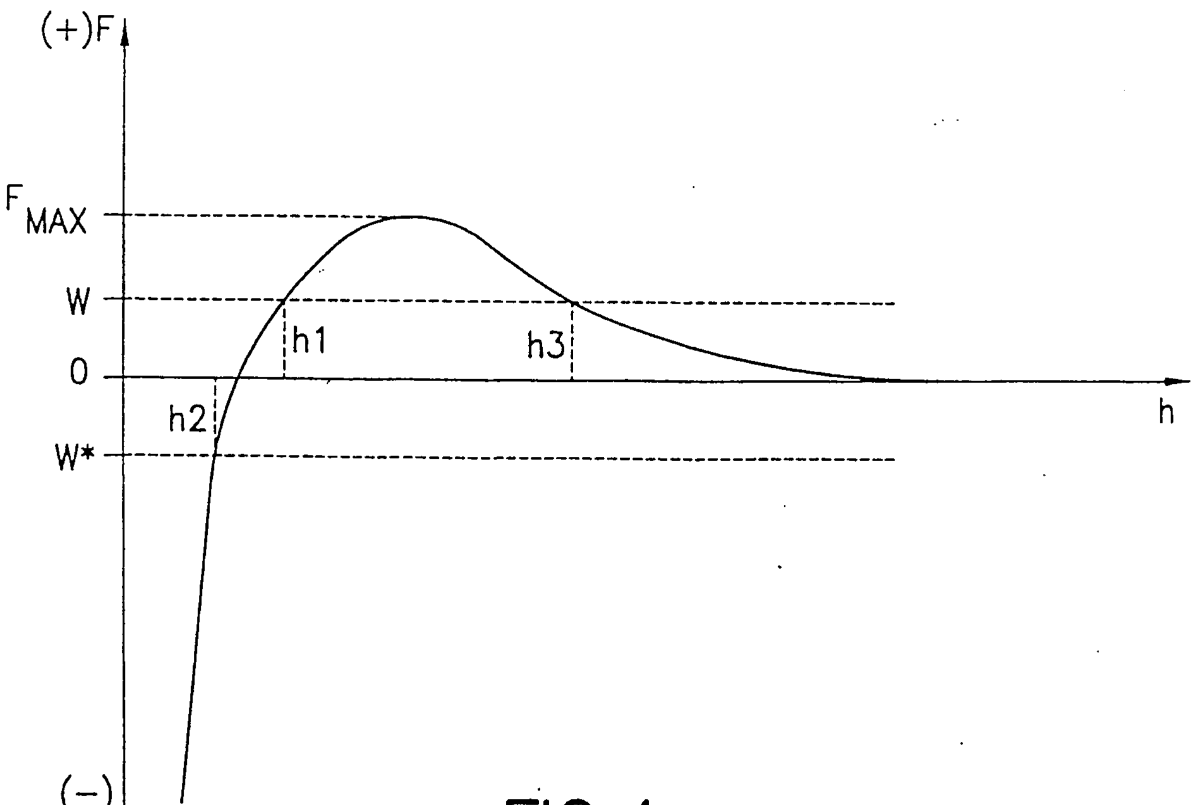

FIG.4

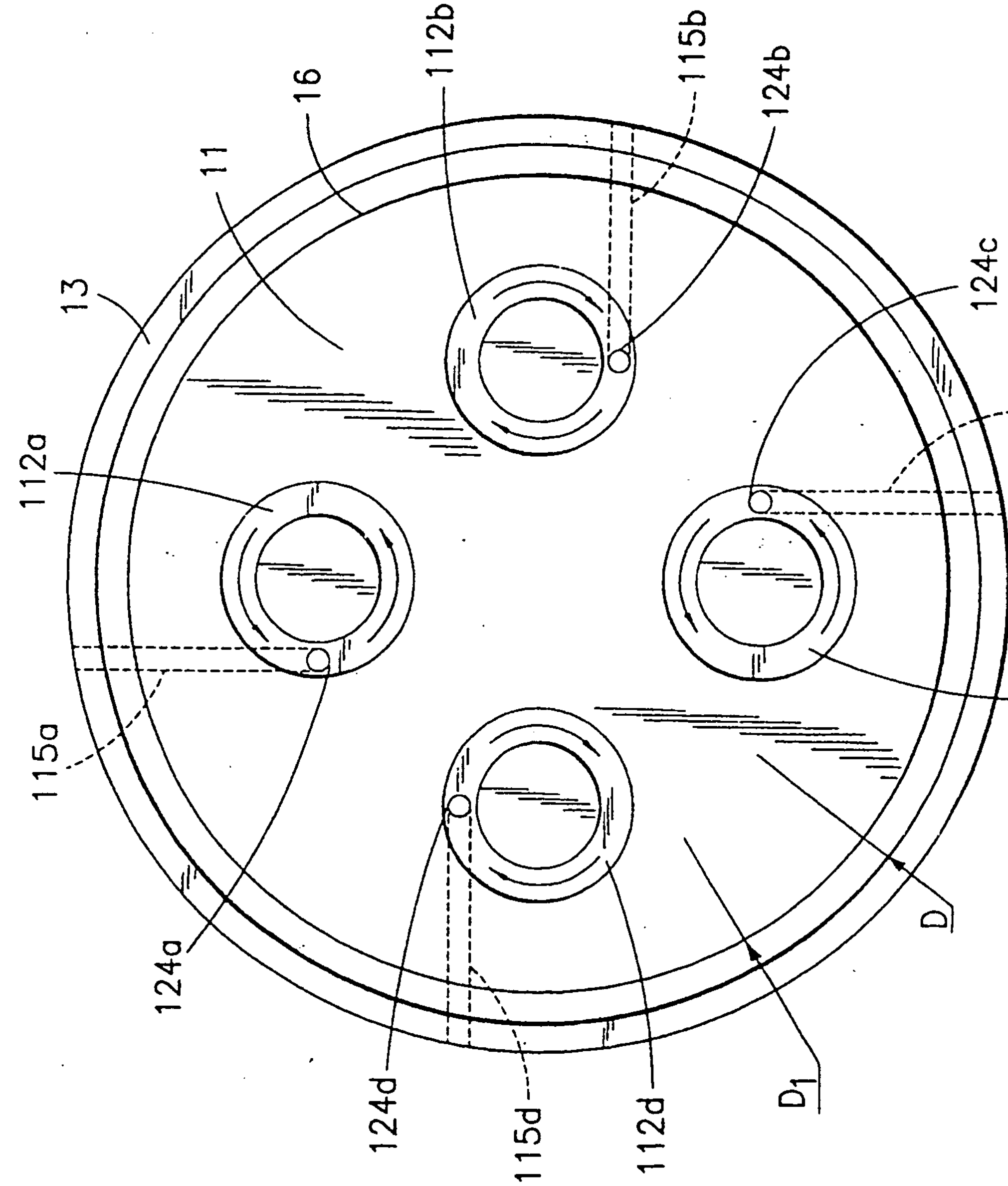
13
11
16
112b
115b
124b
124c
115c
112a
112c
115a
124a
124d
115d
112d
D_1
D

FIG.5

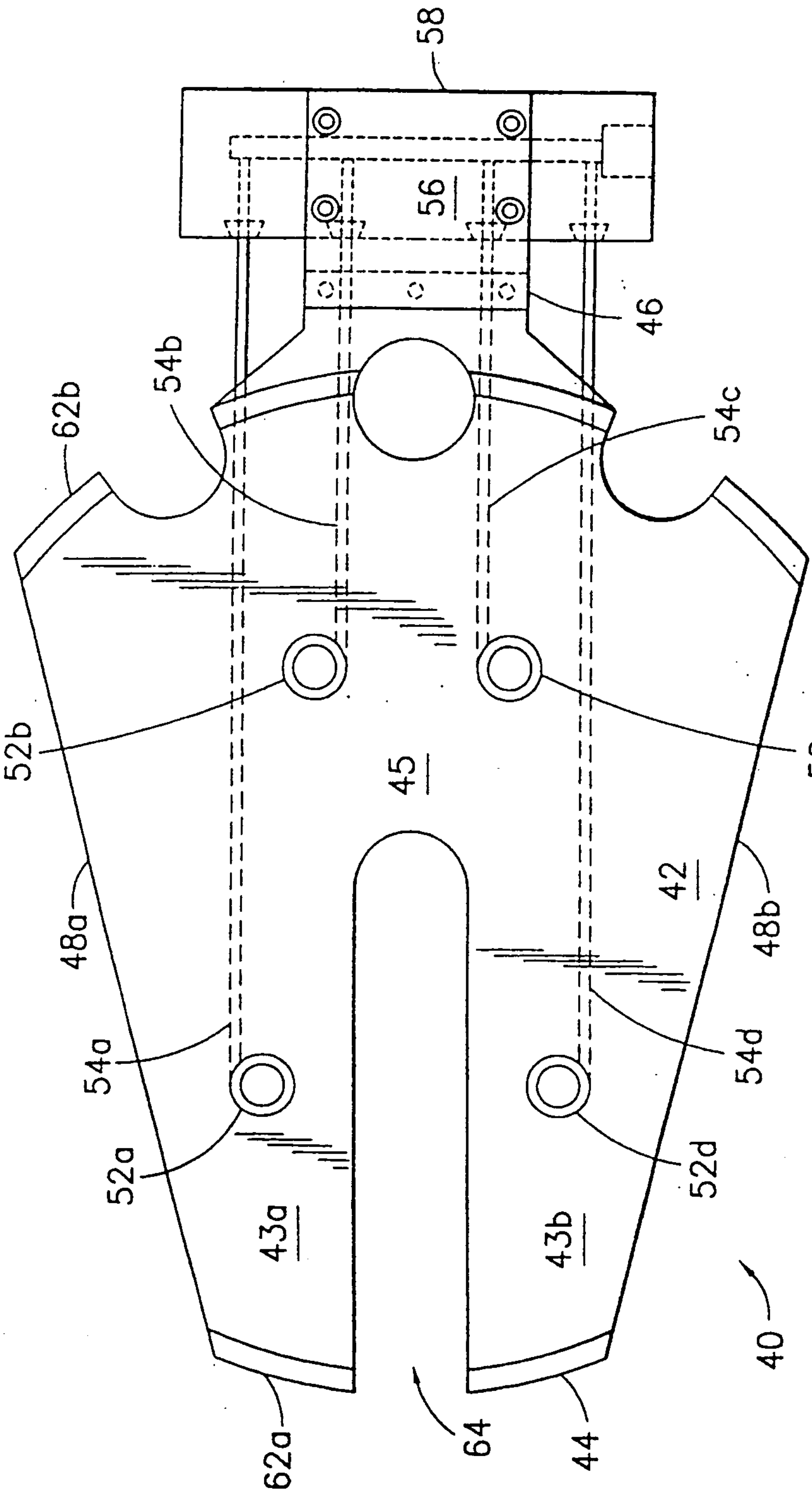
58
56
46
54b
54c
62b
50
52b
52c
45
42
48a
48b
54a
54d
52a
52d
43a
43b
40
62a
64
44

FIG.6

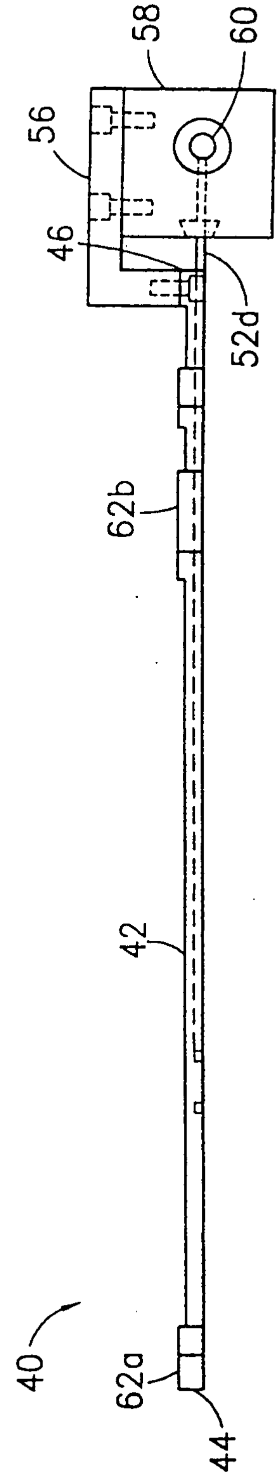
58
60
56
46
52d
62b
42
40
62a
44

FIG.7

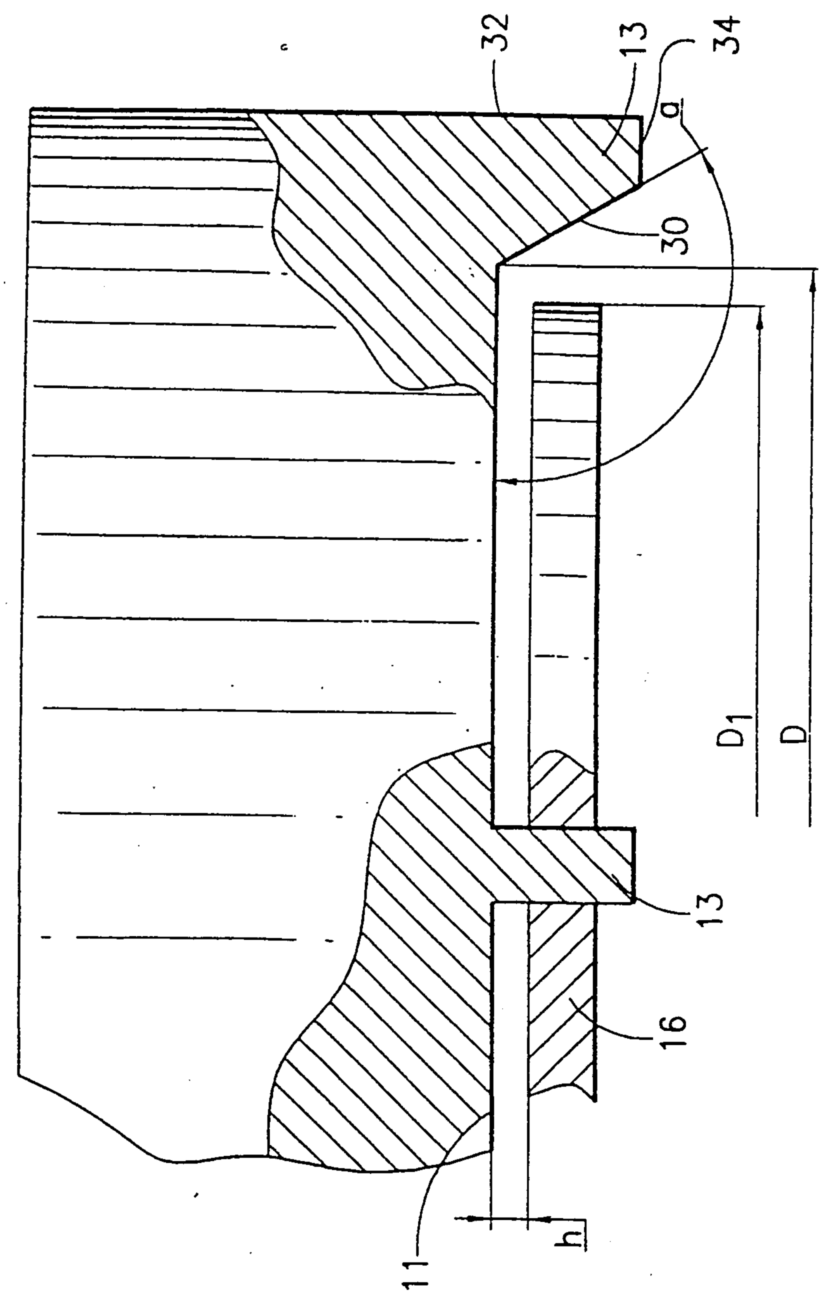

FIG.8

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/08626

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01L21/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01L B25J B65G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 080 549 A (GOODWIN ET AL.) 14 January 1992 see column 14, line 10 - column 14, line 48; figures 15-17 ---	1-4,8, 15,18
A	US 5 067 762 A (AKASHI) 26 November 1991 see column 8, line 27 - column 8, line 53; figures 15,16,25 ---	1
A	EP 0 201 240 A (KABUSHIKI KAISHA SEIBU GIKEN) 12 November 1986 see the whole document ---	1
A	PATENT ABSTRACTS OF JAPAN vol. 17, no. 209 (E-1355), 23 April 1993 & JP 04 348052 A (KYUSHU ELECTRON METAL CO LTD), 3 December 1992, see abstract -----	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 September 1997	26. 09. 97

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	Bolder, G

INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern. al Application No
PCT/US 97/08626

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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